IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
REQUEST FOR FILING NATIONAL PHASE OF
PCT APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

To: Asst. Commissioner of Patents   (Our Deposit Account No. 03-3975)
      and Trademarks
      Washington, D.C. 20231

_____

TRANSMITTAL LETTER TO THE UNITED STATES   Atty Dkt: **PM** 265154
                                                 /T296069US/BR/KOP
DESIGNATED/ELECTED OFFICE (DO/EO/US)   **M#**   /Client Ref.

From: Pillsbury Madison & Sutro LLP, IP Group: Date: December 14, 1999

This is a **REQUEST** for <u>FILING</u> a PCT/USA National Phase Application based on:

1. International Application	2. International Filing Date	3. Earliest Priority Date Claimed
PCT/FI98/00548	23 JUN 1998	23 JUN 1997
⇧ country code	Day MONTH Year	Day MONTH Year (use item 2 if no earlier priority)

4.   Measured from the earliest priority date in item 3, this PCT/USA National Phase Application Request is being filed within:

(a) ☐ 20 months from above item 3 date   (b) ☒ 30 months from above item 3 date,

(c) Therefore, the due date (<u>unextendable</u>) is   <u>DECEMBER 23, 1999</u>

5.   Title of Invention <u>RECEPTION METHOD AND RECEIVER</u>

6.   Inventor(s)   <u>HOTTINEN, Ari et al</u>

Applicant herewith submits the following under 35 U.S.C. 371 to effect filing:

7.   ☒ Please immediately start national examination procedures (35 U.S.C. 371 (f)).

8.   ☐ **A copy of the International Application** as filed (35 U.S.C. 371(c)(2)) is transmitted herewith (file if in <u>English</u> but, if in foreign language, file only if <u>not</u> transmitted to PTO by the International Bureau) including:

a. ☐ Request;
b. ☐ Abstract;
c. ___ pgs. Spec. and Claims;
d. ___ sheet(s) Drawing which are ☐ informal ☐ formal of size ☐ A4 ☐ 11"

9.   ☒ **A copy of the International Application has been transmitted by the International Bureau.**

10. **A translation of the International Application** into English (35 U.S.C. 371(c)(2))
a.   ☒   is transmitted herewith including: (1) ☒ Request; (2) ☒ Abstract;
          (3) <u>12</u> pgs. Spec. and Claims;
          (4) <u>1</u>   sheet(s) Drawing which are:
                    ☐ informal ☒ formal of size ☒ A4 ☐ 11"
b.   ☐   is not required, as the application was filed in English.
c.   ☐   is not herewith, but <u>will be filed when required</u> by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.
d.   ☐   Translation verification attached (not required now).

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RE: USA National Filing of PCT/ FI98 /00548

11. ☒ **PLEASE AMEND** the specification before its first line by inserting as a separate paragraph:
 a. ☒ --This application is the national phase of international application PCT/ FI98/00548
 filed _____June 23, 1998_____ which designated the U.S.--
 b. ☐ --This application also claims the benefit of U.S. Provisional Application No.
 60/____, filed ____ .--

12. ☐ Amendments to the claims of the International Application **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., before 18th month from first priority date above in item 3, are transmitted herewith (file only if in English) including:**

13. ☒ PCT Article 19 claim amendments (if any) have been transmitted by the International Bureau

14. ☐ Translation of the amendments to the claims **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., of claim amendments** made before 18th month, **is attached (required by 20th month from the date in item 3 if box 4(a) above is X'd, or 30th month if box 4(b) is X'd, or else amendments will be considered canceled).**

15. **A declaration of the inventor** (35 U.S.C. 371(c)(4))
 a. ☐ is submitted herewith ☐ Original ☐ Facsimile/Copy
 b. ☒ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

16. **An International Search Report (ISR):**
 a. Was prepared by ☐ European Patent Office ☐ Japanese Patent Office ☒ Other
 b. ☒ has been transmitted by the international Bureau to PTO.
 c. ☒ copy herewith (2 pg(s).) ☒ plus Annex of family members (1 pg(s).).

17. **International Preliminary Examination Report** (IPER):
 a. ☒ has been transmitted (if this letter is filed after 28 months from date in item 3) in English by the International Bureau with Annexes (if any) in original language.
 b. ☒ copy herewith **in English.**
 c.1 ☐ IPER Annex(es) in original language ("Annexes" are amendments made to claims/spec/drawings during Examination) including attached amended:
 c.2 ☐ Specification/claim pages #____ claims #
 Dwg Sheets #
 d. ☐ Translation of Annex(es) to IPER **(required by 30th month due date, or else** annexed **amendments will be considered canceled).**

18. **Information Disclosure Statement** including:
 a. ☒ Attached Form PTO-1449 listing documents
 b. ☐ Attached copies of documents listed on Form PTO-1449
 c. ☒ A concise explanation of relevance of ISR references is given in the ISR.

19. ☐ **Assignment** document and Cover Sheet for recording are attached. Please mail the recorded assignment document back to the person whose signature, name and address appear at the end of this letter.

20. ☐ Copy of Power to IA agent.

21. ☐ **Drawings** (complete only if 8d or 10a(4) not completed): __ sheet(s) per set: ☐ 1 set informal; ☐ Formal of size ☐ A4 ☐ 11"

22. ☐ ___ (No.) **Verified Statement(s)** establishing "small entity" status under Rules 9 & 27

23. **Priority** is hereby claimed under 35 U.S.C. 119/365 based on the priority claim and the certified copy, both filed in the International Application during the international stage based on the filing in (country) FINLAND of:

	Application No.	Filing Date		Application No.	Filing Date
(1)	972704	23 JUN 1997	(2)		
(3)			(4)		
(5)			(6)		

 a. ☒ See Form PCT/IB/304 sent to US/DO with copy of priority documents. If copy has not been received, please proceed promptly to obtain same from the IB.
 b. ☐ Copy of Form PCT/IB/304 attached.

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09/445808 3

420 Rec'd PCT/PTO 1 4 DEC 1999

24.   Attached: Notification of the Recording of a Change (PCT/IB/306)

25.   **Preliminary Amendment:**

25.5   Per Item 17.c2, **cancel original** pages #___, claims #___, Drawing Sheets #

26.   <u>**Calculation of the U.S. National Fee (35 U.S.C. 371 (c)(1)) and other fees is as follows:**</u>
Based on <u>amended</u> claim(s) per above item(s) ☐ 12, ☐ 14, ☐ 17, ☐ 25, ☐ 25.5 (hilite)

Total Effective Claims	26	minus 20 =	6	x $18/$9	=	$0	966/967
Independent Claims	3	minus 3 =	0	x $78/$39	=	$0	964/965
If any proper (ignore improper) Multiple Dependent claim is present,				add$260/$130	+		968/969

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4)): ➔➔ BASIC FEE REQUIRED, <u>NOW</u> ➔➔➔➔
                                                                                    ↓

A.   If country code letters in item 1 are <u>not</u> "US","BR","BB","TT","MX","IL" "NZ", "IN" or "ZA"
                                                                                    ↓
     <u>See item 16 re:</u>   ↓
     1.   Search Report was <u>not prepared</u> by EPO or JPO - - - - - - - - -   add$970/$485   960/961
     2.   Search Report was prepared by EPO or JPO - - - - - - - - - - -   add$840/$420   +970   970/971

<u>SKIP B, C, D AND E UNLESS country code letters in item 1 are "US","BR","BB","TT","MX","IL", "NZ", "IN" or "ZA"</u>
                                                                                    ↓

➔ ☐ B.   If <u>USPTO</u> did not issue <u>both</u> International Search Report
         (ISR) <u>and</u> (if box 4(b) above is X'd) the International   add$970/$485   +0   960/961
         Examination Report (IPER), - - - - - - - - - - - - - - - - - -

➔ ☐ C.   If <u>USPTO</u> issued ISR but not IPER (or box 4(a) above is
         X'd), -   add$760/$380   +0   958/959

➔ ☐ D.   If <u>USPTO</u> issued IPER but IPER Sec. V boxes <u>not all</u> 3
         YES, -   add$670/$335   +0   956/957

➔ ☐ E.   If international preliminary examination fee was paid to
         <u>USPTO and</u> Rules 492(a)(4) and 496(b) <u>satisfied</u> (IPER   962/963
         Sec. V <u>all</u> 3 boxes YES for <u>all</u> claims), - - - - - - - - - -   add $96/$48   +0

27.   **SUBTOTAL =** $970

28.   If Assignment box 19 above is X'd, add Assignment Recording fee of - - -$40   +0   (581)

29.   Attached is a check to cover the -   **TOTAL FEES** $970

Our Deposit Account No. 03-3975
Our Order No.   60256 | 265154
                              C#   M#

CHARGE STATEMENT: The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 and 492 (<u>missing or insufficient fee only</u>) now or hereafter relative to this application and the resulting Official document under Rule 20, or credit any overpayment, to our Account/Order Nos. shown above for which purpose a <u>duplicate</u> copy of this sheet is attached.
This CHARGE STATEMENT <u>does not authorize</u> charge of the <u>issue fee</u> until/unless an issue fee transmittal form is filed

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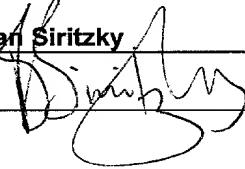
     NOTE: File in <u>duplicate</u> with 2 postcard receipts (PAT-103) & attachments.

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APPLICATION UNDER UNITED STATES PATENT LAWS

Atty. Dkt. No. __PM 265154__

(M#)

Invention: RECEPTION METHOD AND RECEIVER

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This is a:

☐ Provisional Application

☐ Regular Utility Application

☐ Continuing Application

☒ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

☐ Substitute Specification
Sub. Spec Filed _____
in App. No. __/_____

SPECIFICATION

RECEPTION METHOD AND RECEIVER

FIELD OF THE INVENTION

The invention relates to a reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, said signals comprising symbols, and interference elimination and a simultaneous multi-user detection are performed to said signal and in which method an estimate is generated for the received signal.

The invention further relates to a reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, and interference elimination and a simultaneous multi-user detection are performed to said signal.

DESCRIPTION OF THE PRIOR ART

The present invention is applicable in radio systems of several different types, for example CDMA systems. The CDMA is a multi-access method based on spread spectrum technique, and the method has recently been applied in cellular radio systems in addition to the previous FDMA and TDMA systems. The CDMA has several advantages over the previous methods, such as the simple frequency planning and spectral efficiency.

In the CDMA method, a narrowband user data signal is multiplied to a relatively broad band by a spreading code which is significantly more broadband than the data signal. Bandwidths used in the known test systems are, for example, 1.25 MHz, 10 MHz and 25 MHz. In connection with the multiplication, the data signal is spread over the whole band to be used. All users transmit simultaneously in the same frequency band. A unique spreading code is used on each connection between a base station and a mobile station, and the user signals can be distinguished from one another at the receivers on the basis of the spreading code of each user. The aim is to select the spreading codes in such a manner that they are mutually orthogonal, in other words they do not correlate with one another.

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The correlators in the CDMA receivers implemented in a conventional way synchronize with a desired signal which is identified on the basis of a spreading code. The data signal is restored to the original band at the receiver by remultiplying it by the same spreading code as in the transmitting

5 phase. The signals that are multiplied by some other spreading code do not, ideally, correlate and restore to the narrow band. Hence, they appear as noise to the desired signal. The aim is to detect the signal of a desired user from among several interfering signals. In practice, spreading codes are not orthogonal and other users' signals impede the detection of the desired signal by

10 distorting the received signal nonlinearily. This mutual interference between the users is called multiple access interference. Similar multiple access interference occurs also in other multiple access methods, such as the TDMA and FDMA.

Numerous reception methods have been developed to eliminate the

15 signal quality degradation caused by multiple access interference. Among these methods are the conventional single-user reception and the methods enabling a simultaneous multi-user detection. In the conventional single-user reception, the received transmission is correlated by a linear, matched filter ignoring all other signals comprised in the transmission than the signal of the

20 desired user. This reception method is rapid to implement but extremely inefficient in multiple access interference elimination.

Methods have been disclosed in which multiple access interference is eliminated from a broadband signal and detection, in turn, is performed to a narrowband signal from which a spreading code is decoded. Such a method is

25 disclosed in Thielecke, *Interference Reduction Applied to Channel Estimation in CDMA Systems*, Proceedings of Vehicular Technology Conference, 1994, Stockholm, which is incorporated herein by reference. However, in practice such methods are difficult to implement since signal processing is performed broadband, in other words on the chip level.

30 An optimal multi-user detector (MUD) comprises a number of linear matched filters and a Viterbi detector. A known linear multi-user detector is the least squares detector (LS detector) which is called a decorrelating detector. This detector requires data about the mutual cross-correlations of the codes used.

35 Furthermore, a drawback of the known methods is that they are developed for static systems, in other words for situations in which the number of

3

users is unchanged. In practice, however, radio systems comprise numerous factors that vary with time and which should be taken into account when designing receivers. New users are introduced to a cell in connection with handover or new calls. The number and quality of interfering signals supplied from

5   adjacent cells also vary constantly.

BRIEF DESCRIPTION OF THE INVENTION

It is an object of the present invention to provide a reception method and a receiver by which the disadvantages of the previous solutions can be avoided. The solution of the invention enables a rapid and accurate synchroni-

10   zation on account of which the quality of connection setup and interference elimination is improved.

This is achieved by a method of the type described in the introduction, the method being characterized in that the estimate comprises one or more estimates of a received user signal, and that the effect of the symbols

15   estimated on the symbol level is subtracted from the received sum signal, whereby a narrowband, symbol-level residual signal is obtained.

This is also achieved by a method of the type described in the introduction, the method being characterized in that an estimate comprises one or more estimates of a received user signal, and that the received sum signal

20   is correlated by a particular spreading code, whereby a first symbol-level signal is obtained, and that the computed estimate is correlated by the same spreading code, whereby a second symbol-level signal is obtained, and that the second symbol-level signal is subtracted from the first symbol-level signal, whereby a narrowband, symbol-level residual signal is obtained.

25   The invention further relates to a receiver in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area, in which method a received signal comprises a sum signal of signals originating from several transmitters, said receiver comprising means for performing interference elimination and a simultaneous multi-user

30   detection to the signal and means for searching signal parameters. The receiver of the invention is characterized in that the receiver further comprises means for removing the effect of the signals of the known users, and means for estimating the parameters of the unknown signals from a narrowband residual signal.

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Several advantages can be achieved by the method of the invention. The method of the invention can rapidly notice dynamic changes, such as the signals of new users or unknown intruders, in the propagation environment of a radio path. In most cases, the solution of the invention also requires less
5   processing capacity than the previous solutions. The solution of the invention requires no major changes in the existing equipment, but it can also be put to use at low cost in the current systems. The preferred embodiments of the invention are disclosed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

10   The invention will be described in closer detail in the following with reference to the examples in accordance with the accompanying drawings, in which

Figure 1 shows a system to which the invention can be applied, and

Figure 2 is a block diagram illustrating the structure of the receiver
15   of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention can be applied to radio systems of several different types, for example CDMA systems. In the following, the invention will be described in connection with the CDMA system without restricting to it.

20   Figure 1 illustrates the structure of a typical cellular radio system. The figure shows two cells 100, 102, each comprising a base station 104, 106. The cell 100 comprises three active terminals 108 to 112 communicating with the base station 104. Correspondingly, the cell 102 comprises two active terminals 116, 118 communicating with the base station 106.

25   The signals of the terminals are received at the base stations and a simultaneous multi-user detection is performed to the received signals. Let us examine the situation of the base station 104. The base station thus communicates with the active terminals 108 to 112 located in its area whose signals 120 to 124 it receives. The sum signal received by the base station antenna
30   also comprises a signal 126 of the terminal located in an adjacent cell, which signal is an interfering one for the receiver. The base station 104 performs the simultaneous multi-user detection by a known MUD algorithm. It thus detects the desired signals 120 to 124 here and removes the effect of the interfering signal 126 from the desired signals. The effect of all other signals, not only the
35   signal supplied from the adjacent cell can, of course, be removed from each

desired signal. This depends on implementation restrictions and the reliability of the estimate.

Let us next take a closer look at the receiver, in this example base station, of the invention by means of the block diagram in Figure 2. The re-
5 ceiver comprises an antenna 200 which receives a sum signal of signals originating from several transmitters. The antenna can be a single antenna or an antenna array comprising two or more antennas. From the antenna, the signal is conveyed to radio frequency parts 202 in which the signal is typically amplified and converted into an intermediate or baseband frequency. From the ra-
10 dio frequency parts the signal is conveyed to sampling means 204, in other words to an analogue/digital converter in which the signal is converted into a digital form by taking samples of it at a desired sampling frequency.

From the sampling means 202 the signal is conveyed to a correlator bank 206 comprising a number of correlators or matched filters, each synchro-
15 nizing with one signal component of a sum signal, which they identify on the basis of the signal parameters. The correlators decode the spread coding of the signals, in other words convert it into narrowband. Narrowband signals 212 are conveyed to a detection unit 208 in which a simultaneous multi-user detection is performed. The soft decisions 214 of the desired signal symbols ob-
20 tained from the detection unit are conveyed to a post-processing unit 216 and forwarded to the other parts of the receiver. In the post-processing unit 216 the signal is deinterleaved and channel-decoded, for example. How the signal is processed after the detection unit is not relevant.

The signal parameters required by the correlator bank comprise the
25 spreading code, the data rate, the relative delay and optionally the amplitude used in the signal transmission. When any of the parameters is changed, the correlator must be updated. The spreading code may change when a user leaves or enters a cell, which may occur in connection with handover or switch-on.
30 Since data on these parameters is important, the receiver must, of course, monitor and estimate these changing parameters. This is performed in a so-called searcher unit 210. The sum signal received from the sampling means 202 is conveyed, in addition to the correlator bank, to the searcher unit 210 which searches for new signal components and their parameters.
35 The signal parameters estimated and computed by the searcher unit 210 comprise the number of active users, the physical channels, the

channel impulse response, the frame parameters and their functions. A correlation matrix between the codes is also computed in the searcher unit. The correlation matrix must be updated when dynamic changes occur on the channel, when the delays and bit rates change. The detection unit uses these

5   data to compute the correlations between the signals in the simultaneous multi-user detection and interference elimination.

In the solution of the invention the operation of the searcher block is significantly alleviated in such a manner that, in addition to the received sum signal, a signal in which the effect of the signals of the known users is re-

10   moved from the received sum signal is introduced as an input to the searcher unit. The parameters of the unknown signals can be significantly more easily estimated from this residual signal than from the original sum signal. The rapid operation of the receiver is important here, especially in connection with packet-form data.

15   When a new signal is found and its parameters are identified, two alternatives exist. If the signal is an interfering one, for example a signal of a terminal belonging to a neighboring cell, the effect of the signal found by means of the estimated parameters is removed from the received signal. If, however, the signal is a desired one, for example a terminal transferring to the

20   area of the cell of the base station and desiring to set up a macrodiversity connection to the base station, the signal found by the estimated parameters is detected by using a simultaneous multi-user detection.

The estimation of the unknown signals may involve different alternatives. A receiver may have some advance information on the signals to be

25   searched. The signals may be supplied from a neighboring cell, for example, whereby the base station of the neighboring cell can transmit the parameters of potential interfering signals in advance. In such a case, the spreading code may be known while the delay is unknown, for example. On the other hand, in a synchronous system the delay may be known while the spreading code is

30   unknown. It is also possible that no parameter of an interfering signal is known in advance. On the other hand, in packet traffic or in connection with a random access transmission the code is known while the delay is unknown, for example.

When some of the parameters of the signals to be searched are

35   known, these data are utilized when other parameters are searched, which, of course, makes the search more rapid.

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For example, if a number of potential intruders is known, it is possible to compute the cross-correlations between the desired users and the potential interfering signals in advance. Next, utilizing the estimated symbols, known delays and codes, the effect of the known signals is removed from the

5   received sum signal. Next, in order to reduce the search window, the unknown signals are searched from the residual signal by utilizing the advance data.

Let us next take a closer look at the mathematical basis of the solution of the invention. The received signal r is described by the formula

$$r = S_1 A_1 b_1 + n$$

10   in which matrix S comprises at time t all codes of the active users, A comprises at time t all channel coefficients of the active users, b comprises at time t all bits of the active users and n is noise. When a new user is introduced to a system, a new column which must be identified appears in matrix S in the above formula.

15   A known method to solve the problem is to correlate the received signal by a known code s_2 which does not belong to matrix S:

$$s_2^H r.$$

On the basis of the correlation it is decided whether the new signal has been transmitted by using the particular code and at what delay the signal has been

20   received. The codes and delays are examined one by one until the transmitter is found out by means of the correlation result.

Another method, which is disclosed in Thielecke above, is to make a decision on performing interference elimination on the basis of a broadband residual signal:

25     $$s_2^H [r - \hat{S}_1 \hat{A}_1 \hat{b}_1],$$

in which the broadband estimate is subtracted from the received signal.

A preferred embodiment of the invention is based on processing the narrowband signal, in other words the signal which is obtained from the outputs of rake branches. In accordance with the method, the estimate of the

30   known signal is generated first

$$\hat{r}_1 = \hat{S}_1 \hat{A}_1 \hat{b}_1.$$

Next, the residual signal is correlated by the code to be searched

$$\hat{z}_{12} = \hat{s}_2^H [\hat{S}_1 \hat{A}_1 \hat{b}_1] = \hat{S}_2^H \hat{r}_1,$$

whereby an interference estimate is obtained for the narrowband signal. Next,

35   the estimated narrowband signal is subtracted from the output of the $\hat{z}_{12}$ rake branches:

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$$z_{r\omega} = z_2 - \hat{z}_{12}$$

and a decision is made on the narrowband residual signal. For the user k, the decision is made from the signal

$$z_{res} + \hat{a}_k \hat{b}_k,$$

5   in which $\hat{a}_k$ is the channel estimate of one user.

The decision can be based on the strength of the residual signal or the channel estimate or amplitude estimate, for example. The residual signal can be combined on the symbol level either coherently or incoherently. The coherent combining can be implemented by transmitting a known training sequence or

10   by means of a decision feedback. If a new signal does not comprise s_2, the signal-to-noise ratio of the residual signal is poor, and, in the contrary case, the operation reduces interference and improves the signal-to-noise ratio significantly. A great advantage of the method of the invention is that there is no need to compute the cross-correlation at any stage, so the method is signifi-

15   cantly simpler to implement, even if the code changes symbol by symbol. On the other hand, if the code remains steady, i.e. unchanged symbol by symbol, the above computation can still be implemented in such a manner that the cross-correlation matrix $S_2^H * S_1$ is computed first and only after it $\hat{A}_1 \hat{b}_1$. Since the code does not change, the amount of computation does not in-

20   crease significantly.

The computation of the narrowband residual signal is still rather a demanding procedure, so the methods that enable less frequent computation are advantageous. A way to do this is to apply a conventional correlator

$$s_2^H r,$$

25   by means of which a number of test delays is searched, among which the correct delay/code most probably is. A more accurate delay/code estimate based on the residual signal $z_{r\omega}$ can be computed for all test delays obtained in this way. Complexity can thus be reduced by the coefficient $|L_1| / |L_2|$, where $|L_1|$ is the number of the searched test delays and $|L_2|$ the number of all pos-

30   sible delays. The computation can, of course, be performed to several test delays in parallel or sequentially one delay at a time.

In another preferred embodiment of the invention, at least one estimate of an interfering signal is removed from the received signal and the parameters of the unknown signals are estimated from the residual signal ob-

35   tained. This alternative is advantageous when a random access signal is involved, for example. In such a case, the interfering signal only produces a

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one-time effect. The effect of the signal can be removed from the received transmission, and the parameters of the unknown signals are estimated from the less interfering residual signal obtained in this way. The interfering signal estimate comprises the complex amplitude, channel coefficient, delay, etc.

5   Let us next take a closer look at the structure of the receiver, in this example the base station, of the invention by means of the block diagram in Figure 2. The receiver thus comprises the correlator bank 206 which comprises a number of correlators or matched filters whose output comprises the signals 212 that are multiplied by known spreading codes and converted into

10   narrowband. The detection means 208 perform interference elimination and the simultaneous multi-user detection to the signals 212.

The receiver further comprises the means 210 for searching signal parameters. The received sum signal is introduced to the searcher means as one input. From the detection means 208, data 218 on the known signal pa-

15   rameters is conveyed to the searcher means. The signal 218 comprises data on the number of the detected signals, the preliminary delay estimates for each signal and the active code set, for example. The searcher means remove the effect of the signals of the known users from the received sum signal and estimate the parameters of the unknown signals from the residual signal, as

20   described above. The parameters 220 computed by the searcher means are conveyed to the correlator bank 206 and to the detection unit 208 to be utilized. The searcher means 210 and the detection means 208 can be advantageously implemented in practice by software, using a signal processor or a multi-purpose processor or, alternatively, discrete components or ASIC cir-

25   cuits.

Even though the invention is described above with reference to the example in accordance with the accompanying drawings, it is obvious that the invention is not restricted to it but can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in 5 which method a received signal comprises a sum signal of signals originating from several transmitters, said signals comprising symbols, and interference elimination and a simultaneous multi-user detection are performed to said signal and in which method an estimate is generated for the received signal, **c h a r a c t e r i z e d** in that

10 the estimate comprises one or more estimates of a received user signal,

and that the effect of the symbols estimated on the symbol level is subtracted from the received sum signal, whereby a narrowband, symbol-level residual signal is obtained.

15 2. A reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, and interference elimination and a simultaneous multi-20 user detection are performed to said signal, **c h a r a c t e r i z e d** in that

an estimate comprises one or more estimates of a received user signal,

and that the received sum signal is correlated by a particular spreading code, whereby a first symbol-level signal is obtained,

25 and that the computed estimate is correlated by the same spreading code, whereby a second symbol-level signal is obtained,

and that the second symbol-level signal is subtracted from the first symbol level signal, whereby a narrowband, symbol-level residual signal is obtained.

30 3. A method as claimed in claim 1 or 2, **c h a r a c t e r i z e d** in that the parameters of the unknown signals are estimated from the narrowband residual signal.

4. A method as claimed in claim 1, **c h a r a c t e r i z e d** in that a decision whether new user signals have been found is made by means of pa-35 rameters.

5. A method as claimed in claim 3, **c h a r a c t e r i z e d** in that by means of the estimated parameters the found signals are detected using the simultaneous multi-user detection.

6. A method as claimed in claim 1 or 2, **c h a r a c t e r i z e d** in that the received sum signal is first conveyed to a number of matched filters (206) in which the parameters of the known signals are estimated, and said signals are conveyed to a detector (208) in which the simultaneous multi-user detection is performed.

7. A method as claimed in claim 6, **c h a r a c t e r i z e d** in that the signal parameters comprise the signals' phase, amplitude and spreading code used.

8. A method as claimed in claim 6, **c h a r a c t e r i z e d** in that the signal parameters are estimated in parallel.

9. A method as claimed in claim 6, **c h a r a c t e r i z e d** in that the signal parameters are estimated sequentially.

10. A method as claimed in claim 6, **c h a r a c t e r i z e d** in that when some parameters of the unknown signals are known, these data are utilized when other parameters are searched.

11. A method as claimed in claim 1 or 2, **c h a r a c t e r i z e d** in that the residual signal comprises user symbols and that the symbols are combined incoherently.

12. A method as claimed in claim 1 or 2, **c h a r a c t e r i z e d** in that the residual signal comprises user symbols and that the symbols are combined coherently.

13. A method as claimed in claim 1 or 2, **c h a r a c t e r i z e d** in that the parameters are estimated in several stages in such a manner that preliminary estimates are searched first, whereupon a more accurate, final estimate is estimated from among the found, preliminary estimates.

14. A receiver in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area, in which method a received signal comprises a sum signal of signals originating from several transmitters, said receiver comprising means (208) for performing interference elimination and a simultaneous multi-user detection to the signal and means (210) for searching signal parameters, **c h a r a c t e r i z e d** in that the receiver further comprises means (210) for removing the effect of the signals of the known users from the received symbol-level sum signal, and

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means (210) for estimating the parameters of the unknown signals from a narrowband residual signal.

15. A receiver as claimed in claim 14, **c h a r a c t e r i z e d** in that the receiver further comprises means (208) for removing, by means of the estimated parameters, the effect of the found signals from the received signal.

16. A receiver as claimed in claim 14, **c h a r a c t e r i z e d** in that the receiver further comprises means (208) for detecting, by means of the estimated parameters, the found signals, using the simultaneous multi-user detection.
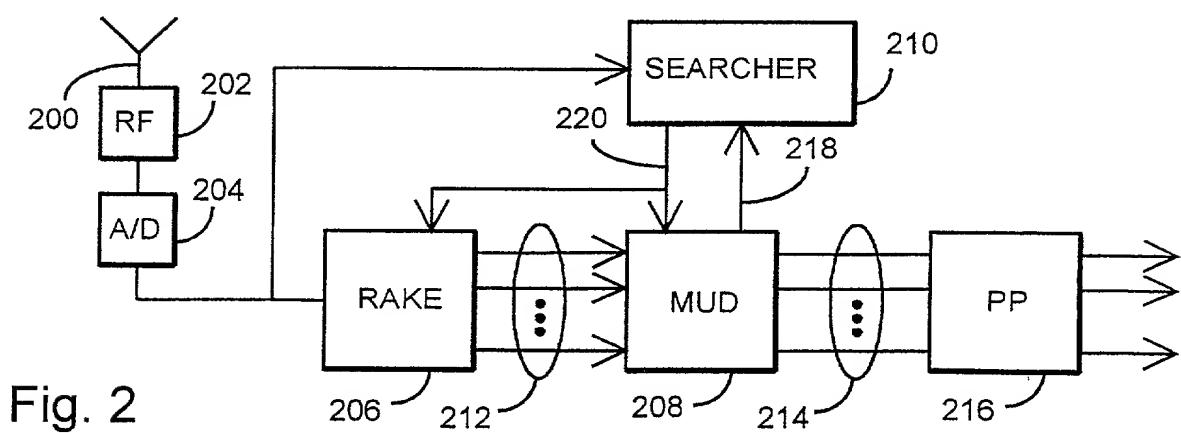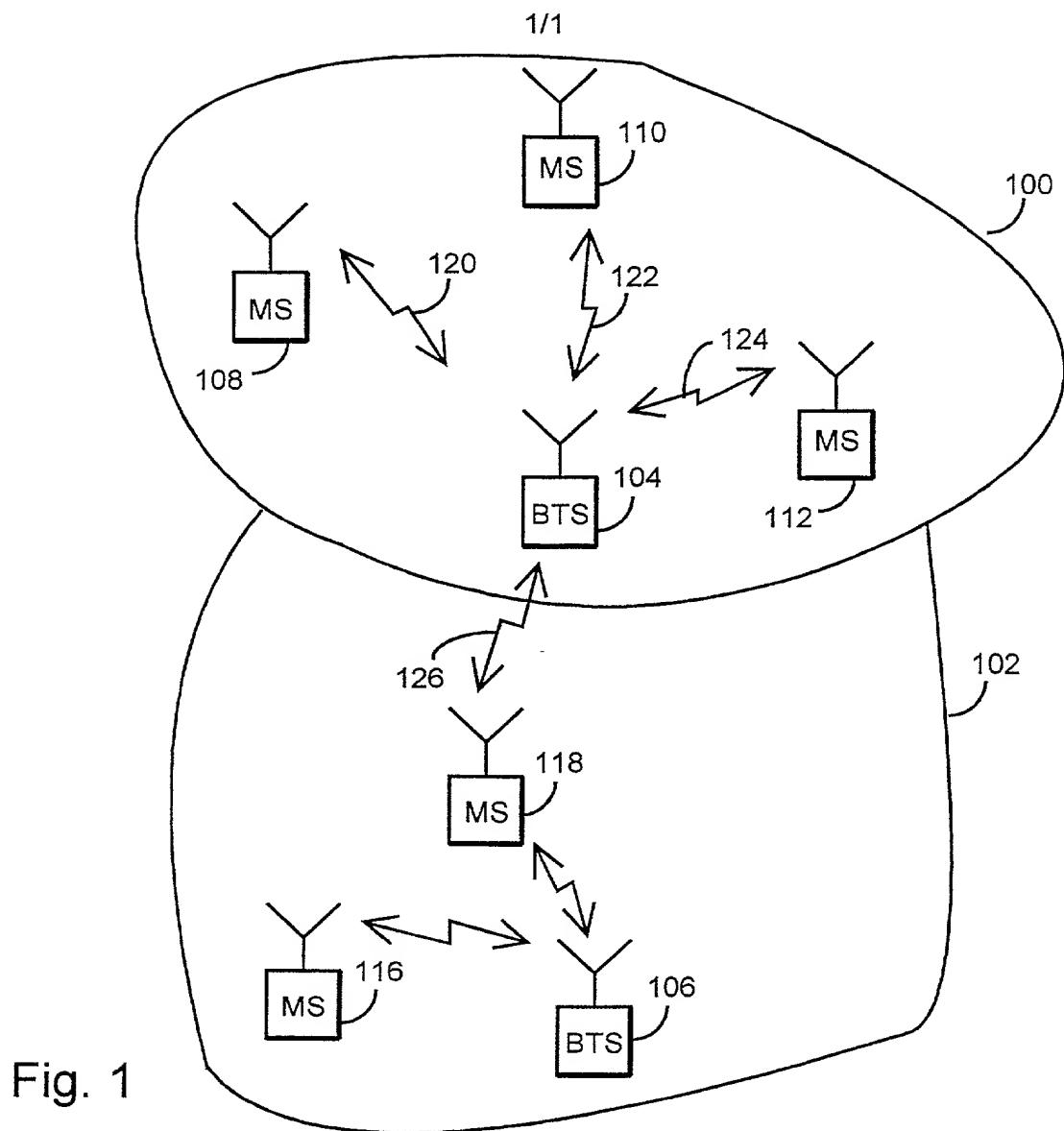
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Fig. 1

Fig. 2

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the **INVENTION ENTITLED** _____
Reception method and receiver

	the specification of which (CHECK applicable BOX(ES))
X	→ A. ☐ is attached hereto.
BOX(ES)	→ B. ☐ was filed on _____ as U.S. Application No. _____ /
	→ C. ☒ was filed as PCT International Application No. PCT/FI98 / 00548 on _____

and (if applicable to U.S. or PCT application) was amended on _____
I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International Application which designated at least one other country than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International Application, filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which priority is claimed, or (2) if no priority claimed, before the filing date of this application:

PRIOR FOREIGN APPLICATION(S) Number	Country	Day/MONTH/Year Filed	Date first Laid-open or Published	Date Patented or Granted	Priority Claimed Yes	No
972704	Finland	23 June 1997			X	

I hereby claim domestic priority benefit under 35 U.S.C. 119(e) or 120 and 365(c) of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application:

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S) Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority Claimed Yes	No

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And I hereby appoint Pillsbury Madison & Sutro LLP, Intellectual Property Group, 1100 New York Avenue, N.W., Ninth Floor, East Tower, Washington, D.C. 20005-3918, telephone number (202) 861-3000 (to whom all communications are to be directed), and the below-named persons (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete names/numbers below of persons no longer with their firm and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above Firm and/or a below attorney in writing to the contrary.

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DECLARATION AND POWER OF ATTORNEY
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